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SELF-COMPACTING ECO CONCRETE: INNOVATION OF FLY ASH AND MARBLE WASTE AS ENVIRONTMENTALLY FRIENDLY AND HIGH QUALITY CONCRETE MATERIALS

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The development of construction in Indonesia is increasing every year, the data shows that Indonesia is the largest market of construction services in ASEAN with value of 267 billion US dollars (Kompas.com 2015). This leads to the increasing need of construction materials such as concrete. With this condition, it will harm the environment because the concrete mix materials are found in nature such as cement and sand. From the problem, the researchers innovate concrete material from fly ash and marble waste with Self Compacting Concrete method. The purpose of this innovation was to produce high quality, economical and environmentally friendly concrete with Self Compacting Concrete (SCC) method. The researchers conducted V-funnel test, L.Box test, Slump Flow test and compressive strength of concrete. From the data obtained, V-funnel test on concrete was able to flow in 4 sec, L.Box had a concrete surface comparison of 1 cm, Slump Flow test had diameter of 85 cm on concrete with FC quality number 1, and the result of compressive strength of concrete was 34-45 Mpa with a preliminary design of 35 Mpa, but this result was obtained at the age of 7 days and it would get stronger at the age requirement of 28 days. The price of concrete in the market was currently IDR 1,100,000-/m^3, while the SCC concrete with additional material of fly ash and marble waste was obtained the price of IDR 792,156,-/m^3. So, it could save the time of 21 days and save the cost of IDR 307,800,-. Fly ash served as a replacement of cement by 30%, while marble was the replacement of aggregate to obtain maximum quality of concrete so that the concrete had called environmentally friendly. By this innovation, it can be obtained timesaving, low cost estimation, high compressive strength and environmentally friendly concrete.

Keywords: Environmentally Friendly, Fly Ash, Marble, Self Compacting Concrete, Waste.

1. INTRODUCTION

The construction industry in Indonesia is growing, both in terms of innovation methods of implementation, material innovation, and the development of knowledge that contribute to the growth and improvement of performance and productivity in the construction industry. It can be seen from the development of methods or materials making up the construction itself. One needs that play an important role in the field of construction industry is concrete work. Concrete is a composite material of its constituent materials. Concrete's forming materials broadly divided into two kinds, they are basic materials and additive ingredients. The base materials form the cement which is required as a binder, fine aggregate which can be either natural sand or stone dust form as a by product of broken stone and coarse aggregate in the form of rock that has a lot of variations in

size which must conform to standards or be crushed or split and water which when mixed with cement will experience the bonding and hardening followed by the release of heat, while the additive materials or admixture which are mixed at the time of manufacture of the concrete used to achieve certain goals.

Normal concrete is generally use basic ingredients aggregate, cement, and water. While the use of concrete admixture given a more specific name in accordance with the specifications, such as High Strength Concrete or High Strength Concrete, concrete pouring or Self-compacting Concrete and so forth. The existence of a variety of concrete construction is due to the need for better quality of concrete. So that in our proposal is about developing Self-compacting Concrete with quality of FC 35 with the addition of fly ash, marble waste, and addictive viscocrete 1003 to obtain high quality and low cost Self-compacting Concrete. So that if this SCC concrete applied in the industry will give benefit on the developer of this SCC concrete.

The goal of innovation Self-Compacting Concrete is to obtain a high quality concrete mix but saving in material usage, such as efficient in the use of cement and water. In addition through the quality concrete experiments FC 35 with three days of testing, got results of the compressive strength is 100%, whereas according to standard set at 40%. Therefore, by using concrete Self-compacting concrete that appropriate at concrete quality FC 35 will save jobs due to 3 days maximum works.

1. METHODOLOGY

Research carried out for 5 months, in the Varia Usaha Beton Company Laboratory, Semarang, and in the Civil Engineering Building Materials Laboratory, Faculty of Engineering, University of Diponegoro.

1. Tools

   Concrete mold tube in 15 x 30 cm diameter, Mesh, molen, oven, slump test, L-Box, V-Funnel, dan Universal Testing Machine (UTM).
2. Materials

   Cement, sand, stone split, fly ash, marble waste, addictive superplasticizer (viscocrete 1003) and water.

1.1. Mixture of Self-compacting Concrete FC 35

Stirring the mixture of sand, cement, fly ash, marble waste, and 60% of the water pouring into the concrete mix further mixes superplasticizer viscocrete 1003 into 20% of the residual water then mix them into the mixture of concrete and crushed stone into the concrete mix until evenly, and added water slowly until the concrete looks flow. For testing fresh concrete, the first test Slump Flow to determine the flowability and stability of SCC. Second, enter the wet concrete into the L-Box to observe the material characteristics of the flowability, blocking and segregation. The third insert fresh concrete into the V-Funnel to measure the filling ability and stability of fresh concrete.

1.2. Analysis and Examination

Quality FC 35 SCC concrete concept is virtually identical to conventional concrete with DOE or ACI method. The experiment in a test using 378 kg cement, 15% marble waste and 31% coarse aggregate, the amount of fine aggregate that used is more than conventional concrete in general, approximately 50% of the volume of concrete. In addition the maximum size of coarse aggregate used must be less than ¾ inch so that coarse aggregates can pass between reinforcement

interrupted, so that the concrete compaction can be achieved well without vibrators. SCC should have good flowability but maintains the ratio of water/cement. It can be achieved by adding a plasticizer to the dose of each product.

The gap of our research is using marble waste. Because, it contains calcium that can be react with cement and cement contains calcium too.

Concrete testing conducted at the Laboratory of Varia Usaha Company include SCC wet concrete test, the slump flow test system, testing concrete compressive strength of hard SCC.

2. RESULT AND DISCUSSION

2.1. Materials Characterization

2.1.1. Properties of Cement

Clinker cement reacts with water to form CSH gel that becomes a binder with filler in concrete.

Table 1: Properties Of Gresik Portland Cement

Density (T/m^3)			Surface Area (cm^2/g)			
2,58			2870			
Chemical Composition (%)						
SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Etc
54,5	23,0	5,3	9,5	2,0	0,5	5,2

2.1.2. Properties of Flyash

Fly ash which is used comes from coal combustion waste in Jepara power plant, type F fly ash with the properties shown in Table 2.

Table 2: Properties Of Flyash

Density (T/m^3)	Surface Area (cm^2/g)	Bonding Time (minute:hours)		Commprssive Strength (kg/cm^2)		
		First Bonding	Second Bonding	Day 3	Day 7	Day 28
3,15	3289	1:58	2:30	22,6	31,6	38,7
Composition (%)						
SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	etc
21,7	5,7	3,2	63,1	2,8	2,2	1,3

2.1.3. Properties of Marble Waste

Marble waste is a leftover from the marble rock fragments that have escaped ⍉ 1.18 mm sieve. Function of marble waste as a filler of a concrete mix. Marble is a leftover waste from themarble rock fragments that have escaped ⍉ 1.18 mm sieve. Marble waste itself functions as a filler of a concrete mix. Table 1 presents the results of chemical analysis of marble waste testing conducted at the Center for Research and Standardization of Industry and Trade of South Sulawesi Province.

Table 3: Results Of Chemical Analysis Of Marble Waste

No	Parameter	Result
1	Silicon Dioxide (SiO_2)	0,26 %
2	Calcium Oxide (CaO)	53,90 %
3	Magnesium Oxide (MgO)	0,19 %

From the results of chemical analysis showed the marble waste contains Calcium Oxide greatest, above 50%. With the content of Calcium Oxide (CaO) contained in the marble waste allows will have a role as a reinforcement in the concrete mixture.

2.1.4. **Properties of Superplasticizer**

Superplasticizer (SP) plays a role in decreasing the viscosity of the concrete, without reducing the strength of concrete and help in pemandatan without vibrator. Superplasticizer used Sika Viscocrete-1003 is the latest generation of superplasticizer for concrete. In the table below are the results of flow is about 0.8%.

Table 4: Vishconcrete 1003 Standart

Type	Standart
For soft plastic concrete	0.2 - 0.6% by weight of binder
For flowing and self compacting concrete	0.6 - 1.6% by weight of binder

2.1.5. **Charecteristic of Aggregate**

Aggregate roles cavity filler in concrete, and help preformance formation of concrete structures. Sand that is used is ex. Merapi and crushed stone ex. Tayu Jepara

Table 5: Results Summary Analysis Of Sand Ex.Merapi

No	Analysis	Result
1	Delicacy Modulus	2,6
2	Mud	1,13 %
3	Organic Contain	NaOH (color) no 5, clear
4	Spesific weight SSD	2,61
5	Contain weight (loose)	1,36 kg/dm^3
6	Contain original (solid)	1,45 kg/dm^3
7	Contain original SSD (loose)	1,47 kg/dm^3
8	Contain original SSD (solid)	1,63 kg/dm^3
9	Adsorbtion	1,20 %

Tabel 6: The Result Of Stone Analysis 10/20 Ex. Tayu (Jepara)

No	Type of Analisys	Average of Analisys Result	Description
1	Fineness Modulus	7,47	
2	Keausan (Los Angeles)	18,04%	
3	Absorption	1,30%	
4	Sludge Levels	0,80%	
5	Specific Gravity SSD	2,77	
6	Flakiness	6,11%	
7	Original Density (Loose)	1,36 kg/dm³	
8	Original Density (Solid)	1,43 kg/dm³	
9	Density SSD (Loose)	1,41 kg/dm³	
10	Density SSD (Solid)	1,53 kg/dm³	
11	Impact test	11,49%	

2.2. Job Mix SCC Concrete Design High Quality

Job mix design quality in the experiment, named SCC High Quality (experimental design for 40 MPa) weighing 378 kg cement.

Table 7 : Concrete Mix Cement Design

SPESIFICATION : Quality Concrete : f 35
Slump in field 10 cm with tolerance 1 cm
The maximum size of coarse aggregate 30 mm

Material		Spesific Gravity
Fine Aggregate	: Natural Sand ex Merapi	SSD 2.58
Coarse Aggregate	: Marble waste	SSD 2.90
	Stone split ex Jepara ⌀ 10-20	SSD 2.72
Cement	: Gresik Cement Type 1 ex Gresik	3.15
Filler	: fly ash	
Water	: Artetis	2.58
Additive	: Type D ex Plastiment SIKA	1.00
	: Viscocrete 1003	1.17
		1.15

From the calculation above obtained inovation material plan of Self Compacting Concrete for dose 1 m^3: FAS (Cement water factor) : 0.45, Water : 183 liter, Portland Cement (PC) : 378 kg, Fly ash : 67 kg, Sand (54%) : 795 kg, Marble Waste (15%) : 249 kg, Aggregate ⌀ 10-20 mm (31%) : 480 kg, Additive F (Superplasticizer) (1,2%) : 3,94 liter, Density : 2172 kg

2.3. The Result of Concrete Testing Properties

Figure 1: Flow Test

Concrete testing performed by the slump flow test, where test data obtained slump flow of 850 mm. This is appropriate with 550 up to 850 mm limitation. In flow concrete test , V-Funnel concrete capable of flowing 4 sec, L.Box has a concrete surface comparison 1 cm, Slump Flow test diameter of 85 cm (ASTM Standard).

Figure 2 : Concrete Trial

Concrete cracks in the experiment has grooves that line, this means that the concrete is very strong in the weight-bearing and bonding between the cement paste and aggregate evenly.

2.4. The Result of Strengthness Testing

Compressive strength testing specimen Ǿ cylinder 15 cm x 30 cm specimen was made during 7 days old and performed using a Universal Testing Machine (UTM). Concrete test results FC 35 with 378 kg cement that has been obtained:

Table 8 : The Result of Strengthness Testing

	First Specimen	Second Specimen	Third Specimen
Weight	13,4 kg	13,6 kg	13,15 kg
Compressive force	77.000 kgf	57.000 kgf	66.000 kgf
The field press	176,625 cm^2	176,625 cm^2	176,625 kg/cm^2
The compressive strength of the age of 7 days	43,59 Mpa	32,27 Mpa	37,36 Mpa
The compressive strength of the 28 days	61,05 Mpa	45,19 Mpa	52,32 Mpa

From the results of the testing of three days already showed that compressive strength is about 100%. So this will reduce the use of cement, which is normally 450/m^3 only need to 378 kg/m^3 due to the influence of the fly ash. Job mix of this study was the dose to 40 Mpa concrete but in fact the quality obtained more than 45 Mpa so it is getting stronger.

Table 9 : Bugdeting Of Normal Concrete (Standart Price PT.Varia Usaha Beton Semarang District based Dinas Pekerjaan Umum Jawa Tengah)

Material	Level per 1 m3		Price (IDR)
	weight	Price (IDR)	Normal SCC
Cement	438 kg	1.400	613.200
Fly ash	77 kg	375	28.875
Sand	8,505 kg	74	255.150
Split 10-20 mm	964 kg	68	71.336
Marble waste	767 kg	100	52.156
Water	175 kg	35	6.125
Aditif	2,93 kg	35.000	102.550
TOTAL PRICE			1.129.392

Table 10 : Bugdeting Of Inovation Concrete (Standart Price PT.Varia Usaha Beton Semarang District based Dinas Pekerjaan Umum Jawa Tengah)

Material	Level per 1 m3		Price (IDR)
	weight	Price	Inovation SCC
Cement	378 kg	1.400,-	529.200
Fly ash	67 kg	375,-	25.125
Sand	964 kg	74,-	71.336
Split 10-20 mm	480 kg	68,-	32.640
Marble waste	249 kg	100,-	24.900
Water	183 kg	35,-	6.405
Aditif	2,93 lt	35.000,-	102.550
TOTAL PRICE			792.156,-

From the estimate price results above obtained IDR 792.156 compared with the price of concrete /m^3 currently is IDR 1.129.392 for the quality concrete 45-50 Mpa. So, with this concrete could save the cost of IDR 337.236. It will be a business opportunity and provide benefits for developers.

3. CONCLUSION

The conclusion that can be taken from this innovation are:

- The use of fly ash as much as 35% as a substituent of cement not only saves the use of cement but also increases the compressive strength and workability of the concrete construction due to the shape and size of the fly ash that is finer and smaller than cement. Can reduce the impact of pollution caused by waste marble and fly ash.
- With this SCC in the many benefits that can be as follows: Reduce the length of construction and the amount of wages of workers, compaction and vibration of concrete that is intended to obtain the optimum level of density can be eliminated, Reduces noise disturbing the surrounding environment, such as not using a vibrator compaction, improve quality concrete structures.
- Can save up to IDR 337.236 of SCC in the market each cubic meter.

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REFERENCES

1. ACI Comittee 211. (1993). “Guide for Selecting Proportion for HighVConcrete with Portland Cement and Fly Ash”. ACI Journal.
2. Dehn, F., Holschemacher, K. and Weiβe, D.(2000). “Self-Compacting Concrete (SCC) Time Development of the Material Properties and the Bond Behaviour.” LACER No.5., Leipzig, Germany.
3. Ekaputri, Januarti Jaya. (2011). “Self Compacting Concrete”. Surabaya: ITS Press.
4. M. Wihardi Tjaronge and M. Rusli H.N.(2003). “Pembuatan Bantalan Kereta Api dengan Menggunakan Self-compacting Concrete. Prosiding Simposium VI- (FSTPT) Forum Studi Transportasi antar Perguruan tinggi.” pp. 1-7.
5. Ozbay, Erdogan. et. al. (2008). “Investigating mix proportions of high strength self compacting concrete by using Taguchi method.” Killis: Elsevier.
6. PT.Varia Usaha Beton website: http://www.variabeton.com/
7. Ramadhiani, Arimbi. (2015). “Terbesar di ASEAN, Pasar Konstruksi Indonesia 267 Dollar AS”.Retrieved from: http://properti.kompas.com/read/2015/11/02/130024921/ Terbesar.di.ASEAN.Pasar.Konstruks i.Indonesia.267.Miliar.Dollar.AS
8. Schutter, G. De. (2005). “Guidelines for Testing Fresh Self-Compacting Concrete.” Berlin: EFCA.
9. Schutter, G. De. (2005). “Guidelines for Testing Fresh Self-Compacting Concrete”. Berlin: EFCA.
10. Subakti, Aman. (2010). “Concrete Mixed Design DOE.” Surabaya: ITS Press. Subakti, Aman. (2010). “Teknologi Beton Praktek I”. Surabaya: ITS Press.